

Lower Impact Development Practices

LID is a site design strategy with a goal of maintaining or replicating the predevelopment hydrologic regime through the use of design techniques to create a functionally equivalent hydrologic landscape. Hydrologic functions of storage, infiltration, and ground water recharge, as well as the volume and frequency of discharges are maintained through the use of integrated and distributed micro-scale stormwater retention and detention areas, reduction of impervious surfaces, and the lengthening of flow paths and runoff time.

LID principles are based on controlling stormwater at the source by the use of microscale controls that are distributed throughout the site. This is unlike conventional approaches that typically convey and manage runoff in large facilities located at the base of drainage areas. These multifunctional site designs incorporate alternative stormwater management practices such as functional landscape that act as stormwater facilities, flatter grades, depression storage and open drainage swales. This system of controls can reduce or eliminate the need for a centralized best management practice (BMP) facility for the control of stormwater runoff.

Although traditional stormwater control measures have been documented to effectively remove pollutants, the natural hydrology is still negatively affected (inadequate base flow, thermal fluxes or flashy hydrology), which can have detrimental effects on ecosystems, even when water quality is not compromised. LID practices offer an additional benefit in that they can be integrated into the infrastructure and are more cost effective and aesthetically pleasing than traditional, structural stormwater conveyance systems.

The use of LID practices offers both economical and environmental benefits. LID measures result in less disturbance of the development area, conservation of natural features and can be less cost intensive than traditional stormwater control mechanisms. Cost savings for control mechanisms are not only for construction, but also for long-term maintenance and life cycle cost considerations.

LID measures provide a means to address both pollutant removal and the protection of predevelopment hydrological functions. Some basic LID principles include conservation of natural features, minimization of impervious surfaces, hydraulic disconnects, disbursement of runoff and phytoremediation. LID practices such as Bioretention facilities or rain gardens, grass swales and channels, vegetated rooftops, rain barrels, cisterns, vegetated filter strips and permeable pavements perform both runoff volume reduction and pollutant filtering functions. For additional information, please visit <http://www.mapc.org/LID.html>

Bioretention (Rain Gardens)

Bioretention is an important technique that uses soil, plants and microbes to treat stormwater before it is infiltrated or discharged. Bioretention “cells” are shallow depressions filled with sandy soil, topped with a thick layer of mulch, and planted with dense vegetation. Stormwater runoff flows into the cell and slowly percolates through the soil (which acts as a filter) and into the groundwater; some of the water is also taken up by the plants. Bioretention areas are usually designed to allow ponded water 6-8 inches deep, with an overflow outlet to prevent flooding during heavy storms. Where soils are tight or fast drainage is desired, designers may use a perforated underdrain, connected to the storm drain system.

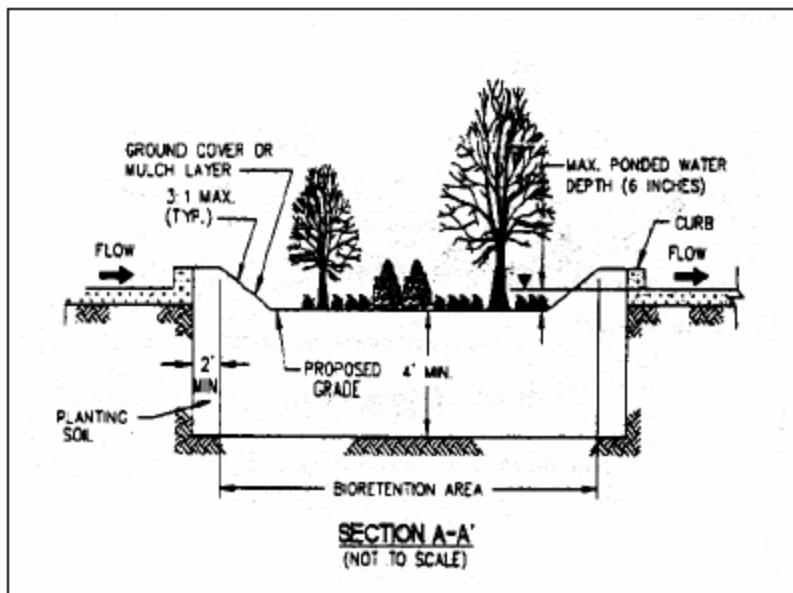


Figure 2: Typical Bioretention System (Prince George's County Department of Environmental Resources, 1993)

Bioretention areas can provide excellent pollutant removal and recharge for the “first flush” of stormwater runoff. Properly designed cells remove suspended solids, metals, and nutrients, and can infiltrate an inch or more of rainfall. Distributed around a property, vegetated bioretention areas can enhance site aesthetics. In residential developments they are often described as “rain gardens” and marketed as property amenities. Routine maintenance is simple and can be handled by homeowners or conventional landscaping companies, with proper

direction.

Impervious surfaces, such as parking lots, are a major contributor to pollutant loads in receiving waters. These surfaces provide a place for pollutants to accumulate and later wash-off in the first flush of rainfall events. Parking lots are good site locations for bioretention systems, since they can be retrofit into existing lots with little or no loss of parking space. In addition, patrons have expressed appreciation of green space within parking areas. The hydrologically functional landscape, can be used as a mechanism for pollutant removal, through physical and biological treatment processes occurring in the plant and soil complex.



Figure 7: The plants in this garden are all hardy and native to the area. This garden is for sunny areas—places receiving more than six hours of direct sunlight per day. Photo: City of Maplewood, Minnesota. Public Works, Engineering Division Rainwater Gardens website (<http://www.ci.maplewood.mn.us>).

Bioretention systems are designed based on soil types, site conditions and land uses. A bioretention area can be composed of a mix of functional components, each performing different functions in the removal of pollutants and attenuation of stormwater runoff

Six typical components are found in bioretention cells:

- Grass buffer strips reduce runoff velocity and filter particulate matter.
- Sand bed provides aeration and drainage of the planting soil and assists in the flushing of pollutants from soil materials.
- Ponding area provides storage of excess runoff and facilitates the settling of particulates and evaporation of excess water.
- Organic layer performs the function of decomposition of organic material by providing a medium for biological growth (such as microorganisms) to degrade petroleum-based pollutants. It also filters pollutants and prevents soil erosion.
- Planting soil provides the area for stormwater storage and nutrient uptake by plants. The planting soils contain some clays which adsorb pollutants such as hydrocarbons, heavy metals and nutrients.
- Vegetation (plants) functions in the removal of water through evapotranspiration and pollutant removal through nutrient cycling.

Bioretention systems can be applied to a wide range of development in many climatic and geologic situations; they work well on small sites and on large sites divided into multiple small drainages. Common applications for bioretention areas include parking lot islands, median strips, and traffic islands. Bioretention is a feasible “retrofit” that can be accomplished by replacing existing parking lot islands or by re-configuring a parking lot during resurfacing. On residential sites they are commonly used for rooftop and driveway runoff.

Bioretention landscaping in Largo, Maryland



Table 1: Example Maintenance Schedule for Bioretention Areas (Prince George's County, Department of Environmental Resources, 1993)

Description	Method	Frequency	Time of Year
Soil			
Inspect and Repair Erosion	Visual	Monthly	Monthly
Organic Layer			
Remulch void areas	By Hand	As Needed	As Needed
Remove previous mulch layer before applying new layer (optional)	By Hand	Once a Year	Spring
Additional mulch added (optional)	By Hand	Once a Year	Spring
Plants			
Remove and replace all dead and diseased vegetation that cannot be treated	See Planting Specifications	Twice a Year	Mar 15–Apr 30 and Oct 1–Nov 30
Treat all diseased trees and shrubs	Mechanical or by Hand	N/A	Varies, depends on insect or disease infestation
Water of plant materials, at the end of the day for 14 consecutive days after planting	By Hand	Immediately after Completion of Projects	N/A
Replace stakes after one year	By Hand	Once a Year	Remove only in the Spring
Replace deficient stakes or wires	By Hand	N/A	As Needed

Maintenance

Annual maintenance is required for the overall success of bioretention systems. This includes maintenance of plant material, soil layer and the mulch layer. A maintenance schedule outlining methods, frequency and time of year for bioretention maintenance should be developed. Table 1 is a typical maintenance checklist. Plants will provide enhanced environmental benefit over time as root systems and leaf canopies increase in size and pollutant uptake and removal efficiencies. Soils, however, begin filtering pollutants immediately and can lose their ability to function in this capacity over time. Therefore, evaluation of soil fertility is important in maintaining an effective Bioretention system.

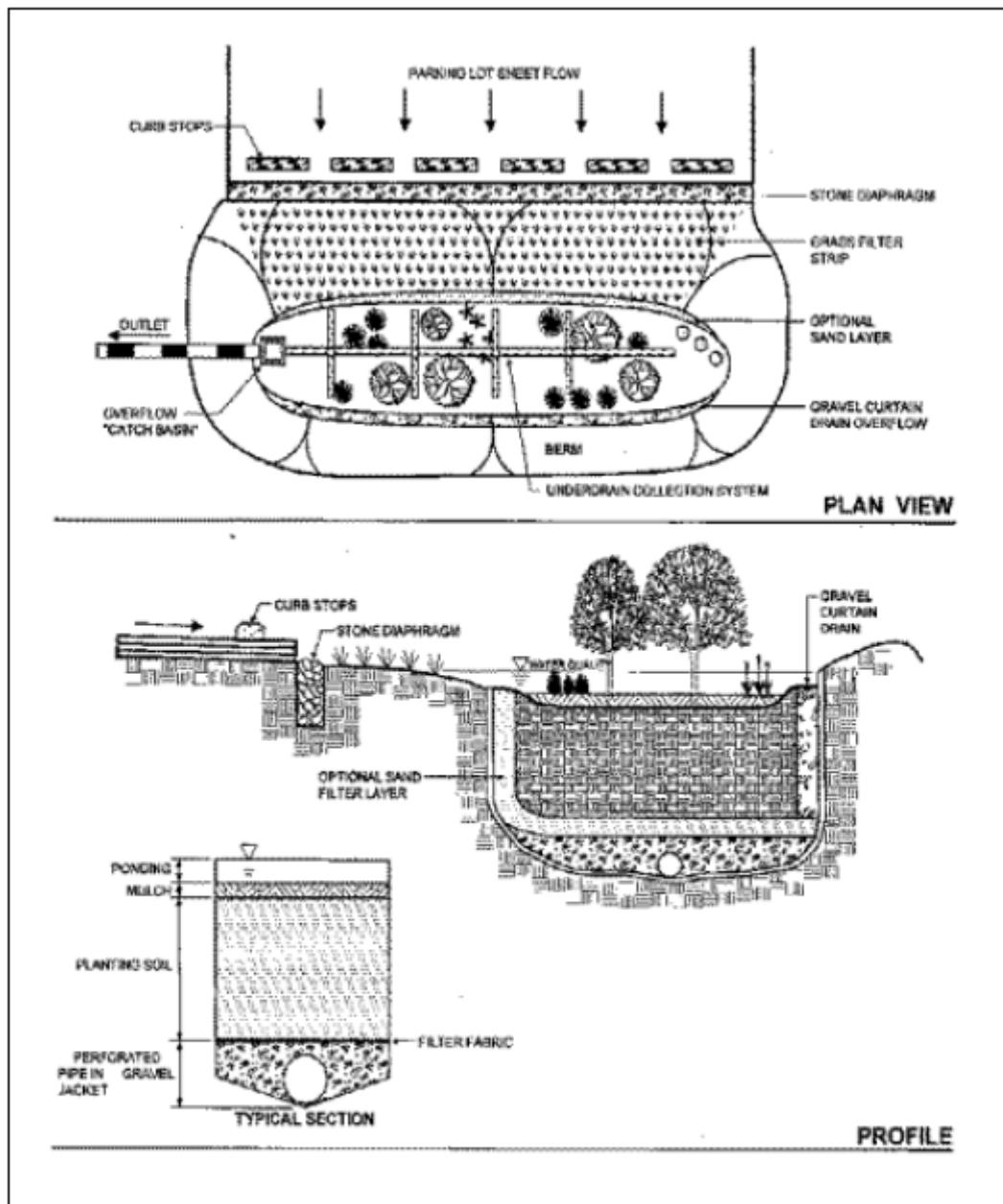
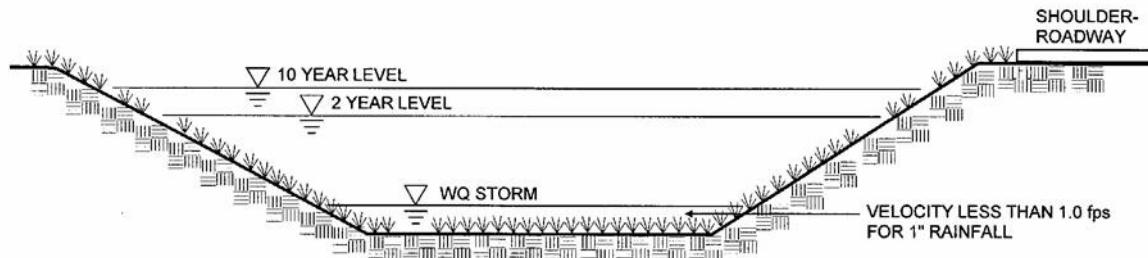


Figure 9: An example bioretention schematic. Image from the Stormwater Manager's Resource Center.

Grass Swales

Grass swales or channels are adaptable to a variety of site conditions, are flexible in design and layout, and are relatively inexpensive (USDOT, 1996). Generally open channel systems are most appropriate for smaller drainage areas with mildly sloping topography (Center for Watershed Protection, 1998). Their application is primarily along residential streets and highways and other areas of low to moderate density. They function as a mechanism to reduce runoff velocity and as filtration/infiltration devices. Sedimentation is the primary pollutant removal mechanism, with additional secondary mechanisms of infiltration and adsorption. In general grass channels are most effective when the flow depth is minimized and detention time is maximized. The stability of the channel or overland flow is dependant on the erodibility of the soils in which the channel is constructed (USDOT, 1996). Decreasing the slope or providing dense cover will aid in both stability and pollutant removal effectiveness.

Vegetated swales may be parabolic or trapezoidal in cross section. Longitudinal slopes should be as low as possible, and never more than 4%. Swales work best in sandy loams that facilitate infiltration; very sandy soils may be prone to erosion under high runoff velocities. Swales should be sized to treat (but not necessarily infiltrate) the entire prescribed water quality volume, and they should convey the entire volume of the 10-year storm event.



Swales are not just ditches under another name—they must be carefully designed and maintained to keep the vegetation in good condition. The vegetation in swales, usually thick grass, helps to trap pollutants (suspended solids and trace metals), and reduce the velocity of stormwater runoff; stormwater also percolates through the natural substrate. Check dams placed along the length of the swale can help to slow the runoff even more and promote greater infiltration and pollutant removal.

Vegetated swales can replace curb and gutter systems as well as storm sewers that convey runoff. Swales require more room than curb and gutter systems but they require less expensive hardscaping; furthermore, the reduction in discharge rate and volume means that downstream treatment facilities can be smaller. Swales also double as landscaping features, increasing the value and attractiveness of the site, as well as its appeal to neighbors and regulatory boards.

Engineered swales are less costly than installing curb and gutter/storm drain inlet and storm drain pipe systems. The cost for traditional structural conveyance systems ranges from \$40–\$50 per running foot. This is two to three times more expensive than an engineered grass swale (Center for Watershed Protection, 1998). Concerns that open channels are potential nuisance problems, present maintenance problems, or impact pavement stability can be alleviated by proper design. Periodic removal of sediments and mowing are the most significant maintenance requirements.

Maintenance:

Like all stormwater management infrastructure, maintenance of swales is critical to their effectiveness and proper function. Permits for water quality swales should specify schedules and responsibility for inspection and maintenance. Swales should be inspected on a semi-annual basis; additional inspections should be scheduled during the first few months to make sure that the vegetation in the swales becomes adequately established. The water quality swales should be inspected for slope integrity, soil moisture, vegetative health, soil stability, soil compaction, soil erosion, ponding and sedimentation.

Swales should be mowed at least once per year, but grass should not be cut shorter than the design flow depth because the effectiveness of the vegetation in reducing flow velocity and pollutant removal may be reduced. Grass cuttings should be removed from the swale and composted. Accumulated sediment should also be removed when it is 3" deep or higher than the turf, to minimize potential concentrated flows and sediment resuspension. Irrigation is only necessary to prevent vegetation from dying. The application of fertilizers and pesticides should be minimal. Periodic reseeding may be required to maintain the dense turf necessary for proper function.

Swales should be inspected after a storm to assess the presence of standing water. Remove trash or obstructions that cause standing water. Care should be taken to protect water quality swales from snow removal and disposal practices and off street parking. Since swales may be located on private residential property, it is important for developers to clearly outline the maintenance requirements to property purchasers.

Cost:

Construction costs are approximately \$0.25/sf, not including design or contingencies (SWRPC, 1991.) Other studies indicate installation costs around \$20 per running foot (Center for Watershed Protection, 1998) Maintenance costs are essentially a function of mowing frequency.

Grass Filter Strips

Grass filter strips are low-angle vegetated slopes designed to treat sheet flow runoff from adjacent impervious areas. Filter strips slow runoff velocities, filter out sediment and other pollutants, and provide some infiltration into underlying soils. Because they use sheet flow and not channelized flow, filter strips are often more effective than swales at removing suspended solids and trash from runoff. They provide good "pretreatment" of stormwater that will then be routed to another technique such as a bioretention area.

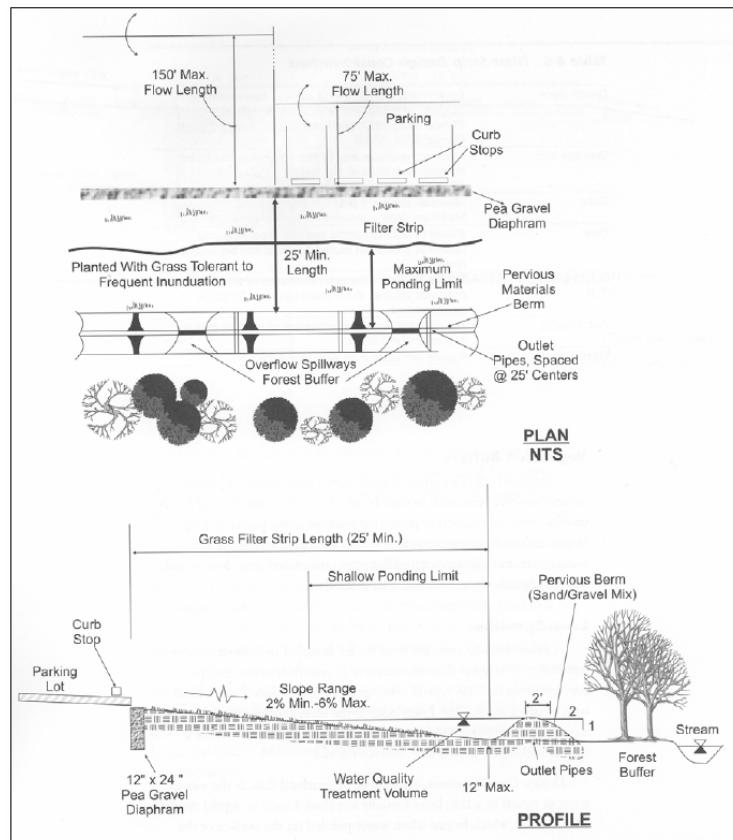
Filter strips differ slightly from buffer strips, which are natural vegetated areas alongside streams and lakes; buffer strips are left undisturbed for habitat protection and visual screening, while filter strips are altered areas designed primarily for stormwater management. Filter strips are appropriate for roadside applications and along the edge of small- to medium-sized parking lots, as long as the tributary area extends no more than 60 feet uphill from the buffer strip. They can also be used to treat roof runoff that is discharged over a level spreader. Filter strips are ideal components of the outer zone of a stream buffer, or as pretreatment to another stormwater treatment practice. They are generally require too much land area for applications in urban areas. The contributing drainage area should generally be less than five acres.

Filter strips provide runoff pretreatment by trapping, filtering and infiltrating particulates and associated pollutants. TSS removal rates range from 40%-90%. Effectiveness depends largely on the quantity of water treated, the slope and length of the filter strip, the type of vegetation, and the soil infiltration rate. They should be combined with other BMPs to ensure adequate treatment of polluted runoff prior to discharge.

Filter strips design should seek to keep runoff velocity in the low to moderate range (less than 2 feet per second) in order to maximize water quality benefits. This can be done by limiting the size of the contributing impervious surface. Both the top and toe of the slope should be as flat as possible to encourage sheet flow. A pea gravel or cement level spreader (with a lip) at the top of the filter strip will improve sheet flow and will capture some sediment.

Maintenance

- Inspect level spreader monthly and remove built-up sediment.
- Inspect vegetation monthly for rills and gullies and correct. Fill any depressions or channels. Seed or sod bare areas.



Source: Prince George's County Bioretention Manual, 2001.

FIGURE 6. TYPICAL GRASS FILTER STRIP

- In the year following construction, inspect the filter strip regularly to ensure that grass has established. If not, replace with an alternative species. Allow natural succession by native grasses and shrubs if it occurs.
- Mow grass, as rarely as 2-3 times per year, to maintain 4" to 6" of dense grass cover. Grass clippings should be collected and composted elsewhere. Provide a minimum of fertilizer only when necessary. Mow when the soil is dry and firm to prevent rutting.
- Semi-annually, remove sediment that has accumulated to prevent berms or channels.

Cost

Filter strips cost considerably less to construct than many hardscaped stormwater management structures such as curbs, storm sewers, and ponds. The primary direct expenses are clearing, grading, and seed or sod. Additional expenses may include construction of a level spreader at the top of the strip or a berm at the toe of the slope.

Rain Barrels Cisterns

Cisterns and rain barrels are simple techniques to store rooftop runoff for reuse for landscaping and other nonpotable uses. They are based on the LID approach that treats rooftop runoff as a resource that should be reused or infiltrated. In contrast, conventional stormwater management strategies take rooftop runoff, which is often relatively free of pollutants, and send it into the stormwater treatment system along with runoff from paved areas.



Figure 10: This rain barrel is used to collect rooftop runoff from a gutter/downspout system. Photo: EPA BMP Factsheets: On-Lot Treatment (<http://cfpub.epa.gov/npdes/stormwater/menufbmps/post.cfm>).

downspout system to direct roof runoff to the storage tank.

Cisterns are partially or fully buried tanks with a secure cover and a discharge pump; they provide considerably more storage than barrels, as well as pressurized distribution. Cisterns can collect water from multiple downspouts or even multiple roofs, and then distribute this water through an electric pump. Property owners may use one large tank or multiple tanks in series. Either way, the overflow for the systems should be a drywell or other infiltration mechanism, so that if the cistern is full, excess roof runoff is infiltrated, and not discharged to the stormwater system. Some cisterns are designed to continuously discharge water at a very slow rate into the infiltration mechanism, so that the tank slowly empties after a storm event, providing more storage for the next event.

Maintenance:

Rain barrels and cisterns require minimal maintenance, but the homeowner needs to ensure that the hose remains elevated during the winter to prevent freezing and cracking. In addition, the tank needs to be cleaned out approximately once per year.

Cost:

Commercially available rain barrels begin at roughly \$60 for a 55-gallon barrel. Larger barrels may be available at correspondingly higher prices. Most rain barrels can be installed by homeowners. Rain barrels can be assembled by homeowners for lower cost but some of the parts may be hard to find. Some watershed associations or municipalities offer rain barrels at a discount or provide rebates.

The most common approach to roof runoff storage involves directing each downspout to a 55-gallon rain barrel. A hose is attached to a faucet at the bottom of the barrel and water is distributed by gravity pressure. A more elaborate and effective technique is to route multiple downspouts to a partially or fully buried cistern with an outlet pump. Where site designs permit, cisterns may be quite large, and shared by multiple households, achieving economies of scale. Stored rain water can be used for lawn irrigation, vegetable and flower gardens, houseplants, car washing, and cleaning windows.

Cisterns and rain barrels are applicable to most commercial and residential properties where there is a gutter and

Cisterns are more expensive due to the larger size and multiple “moving parts.” Installation of buried cisterns can also be expensive. One system available in Massachusetts (SmartStorm) costs \$3000 for an 800 gallon two-tank system complete with pump and drywell structure. A common cistern shared by multiple properties may result in considerable economies of scale because there is only one excavation, one tank, and one pump.

Infiltration Trenches and Dry Wells

Infiltration trenches and dry wells are standard stormwater management structures that can play an important role in Low Impact Development site design. Dispersed around the site, these infiltration structures can recharge groundwater and help to maintain or restore the site's natural hydrology. This approach contrasts with conventional stormwater management strategies, which employ infiltration as a secondary strategy that occurs in large basins at the end of a pipe.

Dry wells and infiltration trenches store water in the void space between crushed stone or gravel; the water slowly percolates downward into the subsoil. An overflow outlet is needed for runoff from large storms that cannot be fully infiltrated by the trench or dry well. Bioretention, another important infiltration technique, is discussed in another fact sheet. Infiltration trenches do not have the aesthetic or water quality benefits of bioretention areas, but they may be useful techniques where bioretention cells are not feasible.

Infiltration trenches and dry wells cannot receive untreated stormwater runoff, except rooftop runoff. Pretreatment is necessary to prevent premature failure that results from clogging with fine sediment, and to prevent potential groundwater contamination due to nutrients, salts, and hydrocarbons.

Infiltration structures cannot be used to treat runoff from portions of the site that are not stabilized.

- Infiltration structures are difficult to apply in slowly permeable soils or in fill areas. Do not use trenches or dry wells where soils are >30% clay or >40% silt clay.
- Where possible, the design should maintain a minimum separation from paved areas (generally 10', depending on site conditions) to prevent frost heave.
- Unlike bioretention areas, infiltration trenches and dry wells do not help meet site landscaping requirements.

Maintenance

- After construction, inspect after every major storm for the first few months to ensure stabilization and proper function.
- On a monthly basis, remove sediment and oil/grease from pretreatment devices, overflow structures, and the surface of infiltration trenches.
- Semi-annually, check observation wells 3 days after a major storm. Failure to percolate within this time period indicates clogging
- Semi-annually, inspect pretreatment devices and diversion structures for sediment build-up and structural damage.
- If ponding occurs on the surface of an infiltration trench, remove and replace the topsoil or first layer of stone and the top layer of filter fabric.
- Upon failure, perform total rehabilitation of the trench or dry well to maintain storage capacity within 2/3 of the design treatment volume and 72-hour exfiltration rate.

Cost

Infiltration structures are moderately expensive to construct. Rehabilitation of failed infiltration trenches and dry wells requires complete reconstruction.

Permeable Pavements

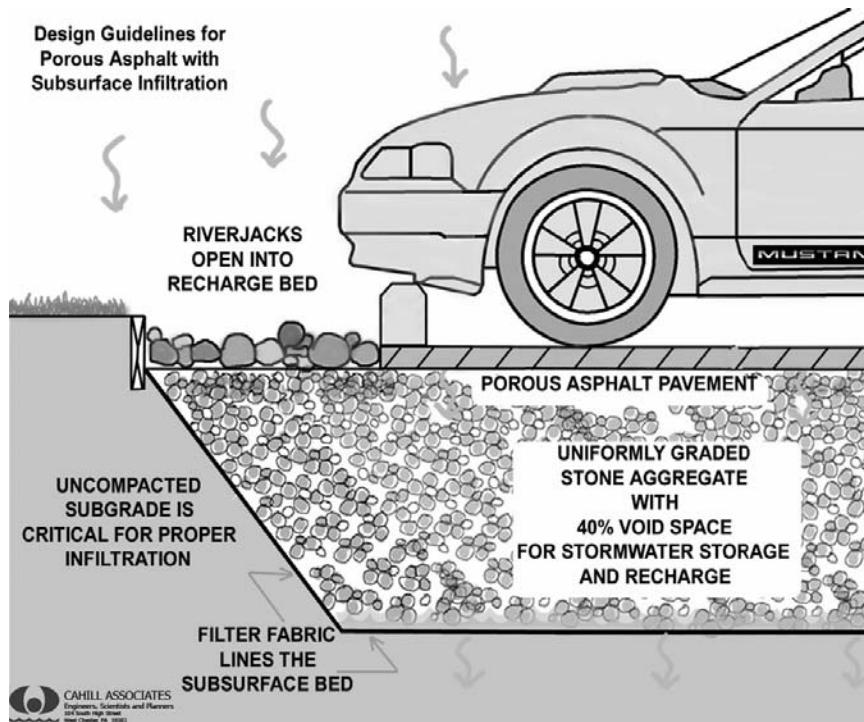
Impervious surfaces are responsible for more stormwater runoff than any other type of land use. Paved surfaces that often replace vegetated areas increase the volume and frequency of rainfall runoff. In addition, these surfaces provide a place for pollutants to accumulate between rainfall events, and are later washed off into receiving waters. Keeping runoff on-site to allow for infiltration as well as chemical, physical and biological processes to take place is the most effective means of reducing pollutant loadings.

All permeable paving systems consist of a durable, load bearing, pervious surface overlying a crushed stone base that stores rainwater before it infiltrates into the underlying soil. Permeable paving techniques include porous asphalt, pervious concrete, paving stones, and manufactured “grass pavers” made of concrete or plastic.

Permeable paving is appropriate for pedestrian-only areas and for low traffic areas such as parking lots and sidewalks, walkways, patios, plazas, and residential driveways. It can be constructed where the underlying soils have a permeability of at least 0.3” per hour. Permeable paving is not well-suited for high traffic/high speed areas because it typically has lower load-bearing capacity than conventional pavement. It should not be used on stormwater “hotspots” with high pollutant loads because stormwater cannot be pretreated prior to infiltration.

The use of permeable pavement systems can dramatically reduce surface runoff volume and attenuate the peak discharge. More than thirty different studies have documented that stream, lake and wetland quality is reduced sharply when impervious cover in an upstream watershed is greater than 10%.

Permeable pavements allow stormwater to infiltrate into underlying soils promoting pollutant treatment and recharge, as opposed to producing large volumes of rainfall runoff requiring conveyance and treatment. A significant contribution of permeable pavements is the ability to reduce effective



impervious area, which has a direct connection with downstream drainage systems. This strategy of hydrologic and hydraulic disconnectivity can be used to control runoff timing, reduce runoff volume, and provide water quality benefits.

Design Details

Permeable Paving

- Permeable paving require a single-size grading of base material in order to provide voids for rainwater storage; choice of materials is a compromise between stiffness, permeability,

and storage capacity. Use angular crushed rock material with a high surface friction to prevent traffic compaction and rutting.

- Choose base materials (crushed stone) that are stable during repeated wetting and drying.
- To promote the growth of microbial populations that will biodegrade pollutants, choose base materials with a neutral or slightly alkaline conditions.

Porous asphalt or concrete:

- Base course is a reservoir layer of 1"-2" crushed stone; depth to be determined by storage required and frost penetration.
- Over the reservoir layer is a 2" thick filter course of $\frac{1}{2}$ " crushed stone.
- The subgrade should be able to sustain traffic loading without excessive deformation. Compaction of sub-base may be necessary to ensure sufficient load-bearing capacity to prevent rutting and deformation.
- A geotextile fabric may be laid at the top of the filter layer to trap sediment and pollutants. This fabric will contain pollutants and prevent clogging of the subsoil; however, this fabric may itself become clogged, requiring removal of the pavement and fabric.

Maintenance

- Post signs identifying porous pavement areas.
- Minimize use of salt or sand during winter months
- Keep landscaped areas well-maintained and prevent soil from being transported onto the pavement.
- Clean the surface using vacuum sweeping machines.
- For paving stones, periodically add joint material (sand) to replace material that has been transported.
- Monitor regularly to ensure that the paving surface drains properly after storms.
- Do not reseal or repave with impermeable materials.
- Inspect the surface annually for deterioration.
- Grass pavers may require periodic reseeding to fill in bare spots.

Cost

Permeable pavement system types vary widely in cost and are more expensive than typical asphalt pavements. Cost comparisons between permeable pavement installations and conventional ponds or underground vaults are limited. However, the elimination of conventional systems and reduced life cycle and maintenance costs can result in significant cost savings over the long term. Costs for paving blocks and stones range from \$2 to \$4, whereas asphalt costs \$0.50 to \$1 (Center for Watershed Protection, 1998).

Constructed Wetlands

Constructed wetlands (or stormwater wetlands) are shallow pools that create growing conditions suitable for marsh plants. They are designed to maximize pollutant removal through retention, settling, and uptake by wetland plants. The primary purpose of constructed wetlands is to improve water quality by removing sediment and pollutants. These wetlands can also provide habitat for wildlife and waterfowl.



Figure 6: Constructed wetland at Spragues Cove in Sippican Harbor in the Town of Marion, MA. Photo: Buzzards Bay Project National Estuary Program, Spragues Cove Stormwater Remediation Project.

See <http://www.buzzardsbay.org/sprafact.htm>.

Constructed wetlands should be designed based on the size of the contributing watershed area, amount of baseflow, soil type, and available space. The contributing watershed may be as small as 5 acres; however, the smaller the watershed area, the more difficult it is to create sufficient drainage and runoff to keep the wetland perpetually wet. Since wetlands need to maintain soil moisture throughout the year, it is important to have a dry-weather baseflow or a groundwater supply.

Maintenance:

Several regular maintenance and inspection practices are needed for stormwater wetlands as outlined below:

- After construction, replace wetland vegetation to maintain at least 50% surface area coverage in wetland plants after the second growing season.
- Inspect for invasive vegetation and remove where possible twice per year.
- Annually inspect for damage to the embankment and inlet/outlet structures. Repair as necessary.
- Annually note signs of hydrocarbon build-up, and deal with appropriately.
- Annually supplement wetland plants if a significant portion have not established (at least 50% of the surface area). Harvest wetland plants that have been “choked out” by sediment build-up if necessary.
- Frequently (3-4 times per year) clean and remove debris from inlet and outlet structures and mow side slopes.
- Removal of sediment from the forebay every 5 to 7 years.
- Annually monitor for sediment accumulation in the facility and forebay. Remove sediment when the pool volume has become reduced significantly, plants are “choked” with sediment, or the wetland becomes eutrophic. If the constructed wetland is designed properly, this should not be required for 20 to 50 years.

Infiltration Drainfields

Infiltration drainfields are innovative technologies that are specially designed to promote stormwater infiltration into subsoils. Infiltration systems are one of the few techniques that provide significant groundwater recharge in areas with a high percentage of impervious surface area. The system is usually composed of a pretreatment structure, a manifold system, and a drainfield. Runoff is first diverted into a storm sewer system that passes through a pretreatment structure such as an oil and grit separator to remove coarse sediment, oils, and grease from the runoff. The stormwater runoff then continues through a manifold system, consisting of a perforated pipe which distributes the runoff evenly throughout the infiltration drainfield. The runoff then percolates through an underlying aggregate sand filter and filter fabric into the subsoils.

See U.S. Environmental Protection Agency (EPA) *Stormwater Technology Fact Sheet: Infiltration Drainfields*. September 1999 for more information.

Maintenance

Routine maintenance of infiltration drainfields is extremely important. The following activities should be performed at the specified frequency:

- The pretreatment device should be checked at least four times per year and after major storm events. The sediment should be cleaned out when the sediment depletes more than 10 percent of the available infiltration capacity.
- Inlet and outlet pipes should also be inspected quarterly.
- The infiltration drainfield should contain an observation well that can provide information on how well the system is operating. It is recommended that the observation well be monitored daily after runoff-producing storm events. If the drainfield does not drain after three days, it usually means that the drainfield is clogged.
- Once performance characteristics of the system have been verified, the monitoring schedule can be reduced to a monthly or quarterly basis.

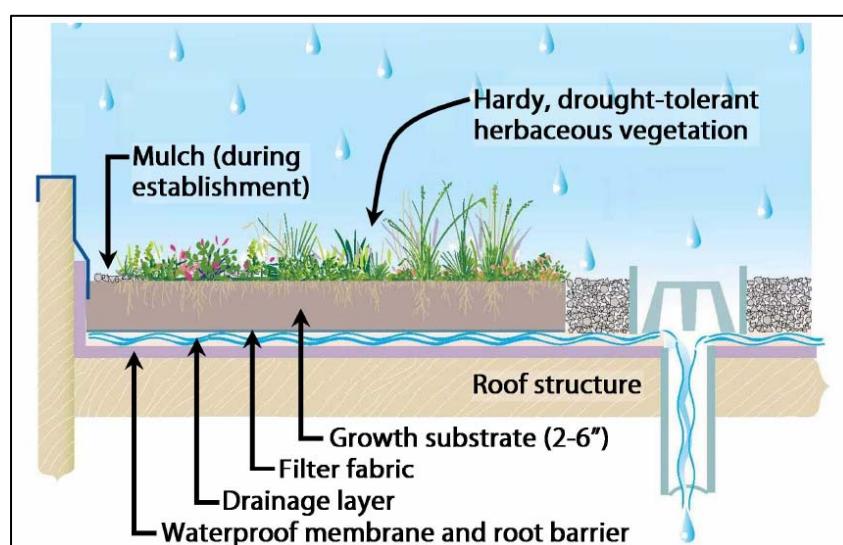
Vegetated Roof Covers – Green Roofs

Vegetative roof covers or green roofs are an effective means of reducing urban stormwater runoff by reducing the percentage of impervious surfaces in urban areas. The green roof is a multilayered constructed material consisting of a vegetative layer, media, a geotextile layer and a synthetic drain layer. Vegetated roof covers in urban areas offer a variety of benefits, such as extending the life of roofs, reducing energy costs and conserving valuable land that would otherwise be required for stormwater runoff controls. Green roofs have been used extensively in Europe to accomplish these objectives, and are now being used in the Northeast.

Using light-weight media and geo-synthetic fibers and membranes, contemporary green roofs can be readily engineered to conform to the load requirements of most roofs. Beautiful vegetated roof covers weighing only 15 pounds per square foot have been installed. This weight is comparable to the weight of gravel ballast placed on many conventional roofs. Where heavier loads can be supported, dramatic landscaping accents can be incorporated, including garden walks, flowering shrubs, and rock gardens. Today, many green roof designs have moved beyond the ecologically utilitarian to incorporate opportunities for passive and active recreation.

Green roofs provide an extra layer of insulation that reduces heating and cooling costs, and they are likely to last much longer than conventional roofs, since the roofing material itself is shielded from ultraviolet light and thermal stress. The vegetation on green roofs also improves air quality, enhances the appearance of the building, and reduces the urban “heat island” effect.

Green roofs are highly effective in reducing total runoff volume. Simple



vegetated roof covers, with approximately 3 inches of substrate can reduce annual runoff by more than 50 percent in temperate climates (Miller, 2000). Research in Germany shows that the 3-inch design offers the highest benefit to cost ratio. Properly designed systems not only reduce runoff flows, but also can be added to existing rooftops without additional reinforcement or structural design requirements. The value of green roofs for reducing runoff is directly linked to the design rainfall event considered.

Green roofs are appropriate for commercial, industrial, and residential structures, especially those with a wide roof area. They can be incorporated into new construction or added to existing buildings during renovation or re-roofing. Most green roofs are built on flat or low-angle rooftops, but some have been installed on pitched roofs up to 40% slope, with special design features to prevent slumping and ensure plant survival.

Maintenance

Green roofs require some support during establishment and then yearly maintenance thereafter. Plants or sprigs should be irrigated until established, and additional plants or sprigs added to ensure good plant coverage if necessary. With drought-resistant vegetation, irrigation of an extensive green roof is rarely necessary after the two-year establishment period. Weeding and

mulching may be needed during the establishment period and periodically thereafter over the life of the roof.

Cost

Green roofs start at \$5 per square foot. They generally cost more to install than conventional roofs, but are financially competitive on a life-cycle basis because of longer life spans (up to 40 years), increased energy efficiency, and reduced stormwater runoff. If the application is a retrofit, structural upgrades may increase the cost somewhat.

Other LID Strategies

Another strategy to minimize the impacts of development is the implementation of rain gutter disconnects. This practice involves redirecting rooftop runoff conveyed in rain gutters out of storm sewers, and into grass swales, bioretention systems and other functional landscape devices. Redirecting runoff from rooftops into functional landscape areas can significantly reduce runoff flow to surface waters and reduce the number of CSO events in urban areas. As long as the stormwater is transported well away from foundations, concerns of structural damage and basement flooding can be alleviated. As an alternative to redirection of stormwater to functional landscape, rain gutter flows can be directed into rain barrels or cisterns for later use in irrigating lawns and gardens. Disconnections of rain gutters can effectively be implemented on existing properties with little change to present site designs.

Many strategies exist to reduce the amount of impervious surface in development areas. Designing residential streets for the minimum required width needed to support traffic, on-street parking and emergency service vehicles, can reduce imperviousness. Other practices include shared driveways and parking lots, alternative pavements for overflow parking areas, center islands in cul-de-sacs, alternative street designs rather than traditional grid patterns and reduced setbacks and frontages for homes.

Landscape Design Standards for Stormwater Treatment

General Standards

Soil and landscaping play an important role in stormwater impacts and treatment results. From a quantity standpoint, the loss of good quality topsoil from many sites during construction results in significant increases in runoff quantities that are often not calculated in the models such as TR-55 typically used for runoff assessment. In terms of quality, high organic content of soils absorbs and adsorbs many pollutants. In fact peat and compost have been shown to provide considerable pollutant removal and are sometimes used in various treatment strategies.

Landscaping also affects stormwater quality and quantity. Grassed areas, while not totally undesirable, may have considerably more runoff due to compaction and more pollutant contribution due to the frequently-occurring overuse of fertilizers and pesticides. Alternatively, a tiered landscape containing an overstory (typically large shade trees), understory trees, shrubs groundcovers provides the most absorption and natural uptake of rainfall. Some grass may be included but typically not an expansive monoculture. A more desirable landscape is diverse and provides wildlife habitat, shade, and beauty along with strips of grass for open areas.

Tiered landscapes, like natural landscapes, tend to require less maintenance and chemical input once established. These landscapes, including a highly organic soil profile, absorb and cleanse rainfall and runoff so that the quantity and quality are more reflective of a natural hydrology. By using these specifications, water, pesticide and fertilizer use will be minimized and vegetation will thrive with little but spring and fall cleanup.

Soil Preparation

1. Compacted soils restrict root penetration, impede water infiltration, and contain few macropore spaces needed for adequate aeration. In addition, compacted soils have a higher runoff coefficient and should be avoided. Preventing construction activities on parts of the site will help prevent compaction. In areas where this is not practical, methods to compensate for the compaction must be employed. Landscape areas should be deep tilled to a depth of at least 12 inches to facilitate deep water penetration and soil oxygenation. Use of soil amendments is encouraged to improve water drainage, moisture penetration, soil oxygenation, and/or water holding capacity. Soil amendments are organic matter such as compost, sewer biosolids, and forestry by-products, but do not include topsoil or any mix with soil as an element.
2. For all newly landscaped areas, including single-family residences, organic matter (three to four cubic yards of organic matter per 1,000 square feet of landscape area) should be incorporated to a depth of four to six inches. Organic content of landscaped soils shall not be less than 18% by volume in the top six inches of the finished topsoil.
3. For newly landscaped areas where topsoil is limited or nonexistent, or where soil drainage is impeded due to subsurface hardpan or bedrock, 6 to 24 inches of sandy loam topsoil should be spread in all planting and turf areas, in addition to the incorporation of organic matter into the top horizon of the imported soil. Organic

content of landscaped soils shall not be less than 18% by volume in the top six inches of the finished topsoil.

4. Soil analysis of new or renovated turf areas should include a determination of soil texture, including percentage of organic matter; an approximated soil infiltration rate; and a measure of pH value.

Mulching

Mulch should be applied regularly to, and maintained in all, planting areas to assist soils in retaining moisture, reducing weed growth, and minimizing erosion. Mulches include organic materials such as wood chips, compost and shredded bark and inert organic materials such as decomposed lava rock, coble, and gravel. If weed barrier mats are used, the use of inert organic mulches is recommended. Non-porous materials, such as plastic sheeting, are not recommended for use in any area of the landscape because of down-slope erosion, potential soil contamination from herbicide washing and increased runoff coefficients. Mulches should be applied to the following depths: three inches over bare soil, and two inches where plant materials will cover. Mulches for stormwater management areas should be heavier and not of a type that will float away.

Compatible Water Use Design

Trees and plants having similar climatic, water, soil, and maintenance requirements should be grouped in distinct and compatible planting areas as follows: (1) plants which, at maturity, require moist soils and supplemental water in addition to natural rainfall to survive; (2) plants which, at maturity, survive on natural rainfall with supplemental water during seasonal dry periods that are unusual due to their length, high temperature, or lack of moisture; and (3) plants which, at maturity, survive on natural rainfall without supplemental water. Grouping/zoning of plantings should coordinate with the irrigation hydrozoning plan as well as topographic features in the landscape so that plantings benefit from collected precipitation, run-off, or water harvesting. Group 3 plantings should be preferred over Group 2 or 1 plantings.

Site Features and Layout

1. Landscaping should be designed to remain functional and attractive during all seasons of the year through a thoughtful selection of deciduous, evergreen, flowering and non-flowering plant varieties.
2. Prominent natural or man-made features of the landscape such as mature trees, surface waters, natural rock outcrops, roadways or stonewalls should be retained and incorporated into the landscape plan where possible. The addition of ornamental rocks, fencing and other features new to the landscape are encouraged.
3. Existing natural vegetation should be retained where possible. Existing trees and shrubs to be retained may be substituted for any compatible required plantings.
4. Lawn areas should be kept to a minimum. Natural re-growth, mulched planting beds and alternative groundcover plant varieties are preferred. Lawn areas should not be planted in strips of less than six feet in width, especially adjacent to roads or parking areas, since such areas require watering but have little utility and are less likely to thrive.
5. Native plant species, or plant species that have been naturalized in the area or the surrounding region should be used to meet the minimum requirements of this section. Plant varieties selected should be hardy, drought and salt resistant, and require minimal maintenance. Less hardy, exotic or higher maintenance plant

varieties may be used to supplement minimum landscaping requirements where appropriate, but are not encouraged. Species listed on the current Invasive Species List for Massachusetts shall not be used.

Use of Compost

Incorporation of organic matter such as compost improves the structure (tilth) of the till and any other soil types, with the exception of soils that are already highly organic. In sandy soils, compost increases the water holding capacity and nutrient retention. The physical and chemical properties of most New England soils can be significantly improved by blending in compost.

Compost-amended soil has many potential benefits when instituted with establishment of turf and landscaping, including: (1) increased water conservation, (2) increased nutrient retention, (3) better turf aesthetics, (4) reduced need for chemical use, (5) improved stormwater retention, and (6) cost-savings to the private landowner, and the Town of Southborough.

Compost shall be a stable, humus-like organic material produced by the biological and biochemical decomposition of source separated compostable materials, separated at the point of generation, that may include, but are not limited to, leaves and yard trimmings, food scraps, food processing residuals, manure and/or other agricultural residuals, forest residues and bark, and soiled or non-recyclable paper. Compost shall not be altered by the addition of materials such as sand, soil or glass. Compost shall contain no substances toxic to plants and shall not contain more than 0.1 percent by dry mass of man-made foreign matter. Compost shall pose no objectionable odor and shall not closely resemble the raw material from which it was derived. Compost shall have a minimum organic matter content of 30 percent dry unit weight basis as determined by loss on ignition in accordance with ASTM D 2974. Compost shall be loose and friable, not dusty, have no visible free water and have a moisture content of 35 - 60 percent in accordance with ASTM D 2974.

The particle size of compost shall be 100 percent less than 25 mm in accordance with AASHTO T27 and shall be free of sticks, stones, roots or other objectionable elongated material larger than 50 mm in greatest dimension. The pH of compost shall be in the range of 5.5 - 8.0. The maturity of the compost shall be tested and reported using the Solvita Compost Maturity Test and must score 6 or higher to be acceptable. The soluble salt content of compost shall not exceed 4.0 mmhos/cm as determined by using a dilution of 1 part compost to 1 part distilled water. The quantity of compost to be incorporated into a site is determined by the final organic content goal for the soil and is dependent on its existing organic content. Organic content of landscaped soils shall not be less than six percent.

Low Impact Development Landscaping

Landscaping that incorporates Low Impact Development (LID) strategies for stormwater management should serve to meet the requirements of the Town of Southborough's stormwater management plan by absorbing and treating stormwater runoff to the greatest extent possible onsite. Low Impact Development landscaping includes the use of biofilters, raingardens, shallow swales, drywells and other features that use soil and landscaping to mimic natural hydrologic features and functions. The high organic content of the soils encourages healthy growth and absorbs and retains rainwater on site as soil

moisture, minimizing irrigation needs and runoff quantities. Landscape areas shall include all areas on the site that are not covered by buildings, structures, paving or impervious surface. The selection and location of turf, trees, ground cover (including shrubs, grasses, perennials, flowerbeds and slope retention), pedestrian paving and other landscaping elements shall be used to absorb rainfall, prevent erosion and meet the functional and visual purposes such as defining spaces, accommodating and directing circulation patterns, managing hardscape impacts, attracting attention to building entrances and other focal points, and visually integrating buildings with the landscape area. Where possible, the landscaping design should combine form and function, incorporating drainage features invisibly into the landscape such as through shallow detention areas, parking lot islands that provide for infiltration of parking lot runoff and sheet flow.

Neighboring Properties

Landscape Design Plans shall mitigate the impact to neighboring properties. The rear elevations of buildings, loading docks, and refuse collection areas must also be addressed in the Landscape Design Plan. It is required that rear elevations adjacent to noncommercial zoned parcels will be screened to the full height of the structure within seven (7) years of occupancy of the retail space.

Parking Lots

Parking lots with more than fifty (50) parking spaces shall have curbed planting areas. Planting areas shall be placed at each end of a parking row. No parking row shall contain 30 contiguous parking spaces without a curbed planting area. Curbs around parking lot planting areas shall have a shallow descending cut that is a minimum of five feet wide to allow drainage to flow from the parking lot into the curbed planting areas for infiltration. Such planting areas shall be underlain by a suitable layer of crushed stone or other water holding reservoir, with an overlay of filter fabric to minimize clogging by fines. Topsoil depths and minimum organic content shall be as above for other landscaped areas for the maximum absorption of rainfall.

Vegetation

Any landscape element that dies, or is otherwise removed, shall be promptly replaced with the same, if not similar to, height or texture element as originally intended. A split rail or picket fence, not less than two feet in height and not more than four feet in height, shall be provided between or to the rear of the trees to serve as a back drop and support for the shrubs and other planting, to serve as a unifying architectural element, and to protect against damage cause by pedestrian "cut-through" traffic. Shrubs and other smaller plantings should be placed between the fence and the street or on both sides where the fence is placed toward the center of the landscaped strip. Landscape strips should be mulched or planted with hardy groundcover plant varieties rather than planted as lawn areas. Where landscape strips are used as part of the drainage system, plantings shall be tolerant of periodic wet conditions and shall be shallowly sloped to allow infiltration and storage.

Wheel stops should be provided in all parking areas abutting landscaped strips to avoid accidental damage.

Collector Roads: A deciduous shade tree and accompanying understory shrubs and groundcovers shall be planted in groupings along the front property line of all sites adjoining the collector road at a rate of not less than 1 tree per 25 linear feet of property

frontage. Where larger shade trees may interfere with overhead utilities, minor shade or ornamental tree varieties should be used.

Maintenance

Low maintenance, drought, insect and disease resistant plant varieties are encouraged so that buffer areas and other required landscaping can be maintained with minimal care and the need for watering, pesticide or fertilized use is minimized. For these reasons, native species and species that have long thrived within the region are preferred since such plant species are well adapted to the local environment.

To avoid maintenance problems, soil testing should be conducted prior to planting to ensure that the appropriate plant varieties are selected for various portions of a site. To avoid maintenance problems and excessive watering, organic matter such as compost or peat should be added to the soil before planting as appropriate to increase the water holding capacity of the soil and to provide nutrients.

Where used, irrigation systems should be installed with moisture meters or other devices designed to avoid unnecessary or excessive watering. Alternatively, irrigation systems should be manually activated.

Informal, Re-growth and Peripheral Landscape Areas

Disturbed areas intended for natural re-growth should be, at a minimum, graded, loamed and seeded with wildflowers, perennial rye grass or similar varieties. The planting of native trees, shrubs and other plant varieties is encouraged. The planting of blueberry, rhododendron, winterberry, bayberry, shrub dogwoods, cranberry bush, spicebush, native viburnums and other hardy shrubs along the edge of cleared woodlands provides for an attractive transition between natural woodland and more formally landscaped portions of a site. Where woodland areas are intended to serve as buffers, such plantings can fill in voids by rapidly reestablishing undergrowth. Perennial flowerbeds are also encouraged.

Plant Specifications and Definitions

1. Trees and shrubs – installation size requirements

- a) Minimum size for shade or canopy trees shall be 3 inches in diameter measured at a point six inches above grade with a height of not less than 12 feet.
- b) Minimum size for small or minor shade trees shall be 2.5 inches in diameter measured at a point six inches above grade with a height of not less than nine feet.
- c) Minimum size for ornamental or flowering fruit trees shall be 2 inches in diameter measured at a point six inches above grade with a height of not less than seven feet.
- d) Minimum size for evergreen trees shall be six feet in height.
- e) Minimum size for shrubs shall be 1.5 feet in height.

2. Planting Specifications

- a) Areas intended as planting beds for shrubs or hedges shall be cultivated to a depth of not less than 18 inches. All other planting beds shall be cultivated to a depth of not less than 12 inches.
- b) Pits for planting trees or shrubs shall be generally circular in outline with vertical sides. Pits for trees or shrubs shall be deep enough to allow oneeighth of the ball of

the roots to be the existing grade. Pits for trees shall be wide enough to allow for at least 9 inches between the ball of the tree and the sides of the pit on all sides.

- c) Cultivated areas shall be covered with not less than a two to three inch deep layer of mulch after planting.
- d) All trees and shrubs shall be appropriately pruned after planting with all broken or damaged branches removed.
- e) All plants shall be nursery grown.

3. Retention of Existing Vegetation

The boundary of areas to be cleared should be well defined in the field with tree markings, construction fencing or silt fencing as appropriate to avoid unnecessary cutting or removal. Care should be taken to protect root systems from damage from excavation or compaction. Individual trees, rock formations and other landscape features to be retained should also be clearly marked and bounded in the field.

Recommended Plant Varieties

See Attachment A

Definitions

- 1. Berm: a linear earthen mound designed to block views, noise or other potentially objectionable circumstances.
- 2. Deciduous: a plant with foliage that is shed annually.
- 3. Evergreen: a plant with foliage that is retained and remains green throughout the year.
- 4. Mulch: nonliving organic or synthetic matter spread over cultivated ground to retain moisture, limit weed growth and control erosion.
- 5. Ornamental tree: a deciduous tree, generally smaller than a shade tree, that is planted primarily for its aesthetic or ornamental value.
- 6. Shade tree: a large deciduous tree with a high crown of foliage or overhead canopy.
- 7. Shrub: A self-supporting woody plant, smaller than a tree, which consists of several small stems or branches from a base at or about the ground.